PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-032045
(43)Date of publication of application : 31.01.2003

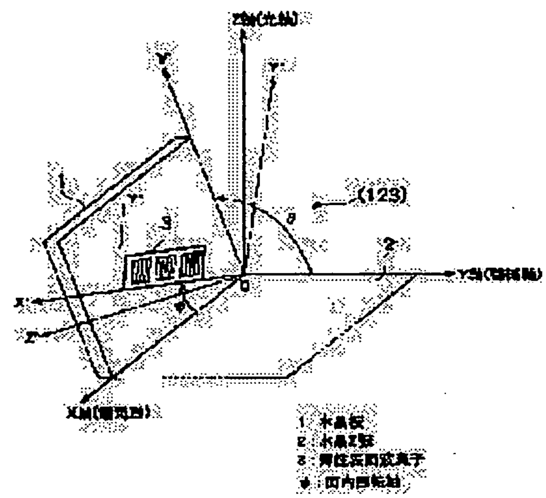
(51)Int.CI. H03B 5/32
H03H 3/04

(21)Application number : 2001-217238
(22)Date of filing : 17.07.2001
(71)Applicant : SEIKO EPSON CORP
(72)Inventor : KOBAYASHI SACHIHIRO
IMAI NOBUYUKI

(54) TEMPERATURE CHARACTERISTIC ADJUSTMENT METHOD FOR PIEZOELECTRIC DEVICE AND OSCILLATION CIRCUIT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a temperature characteristic adjustment method for a piezoelectric device and an oscillation circuit that uses a characteristic of a temperature region lower than an inflection point of a vibrator with a ternary function temperature characteristic so as to make a temperature characteristic of the oscillation circuit more flat within an operating temperature range.

SOLUTION: The temperature characteristic adjustment method is relevant to the piezoelectric device and the oscillation circuit with a ternary function temperature characteristic where the inflection point of the ternary function temperature characteristic is at the outside of an original operating temperature range. Regarding a maximum or minimum point temperature located within a room temperature range as a top temperature with an apparent quadratic function temperature characteristic and turning the temperature characteristic around the inflection point located at the outside of the room temperature range by adjustment of a linear coefficient can adjust the top temperature to be an optimum value within the room temperature range.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision

of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

[JP,2003-032045,A]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] It is the temperature characteristic adjustment method of a piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits. See the maximum point or the minimum point temperature located in an ordinary temperature range, and it is regarded as top-most-vertices temperature of the upper secondary function temperature characteristic. A temperature characteristic adjustment method of a piezo-electric device characterized by rotating the temperature characteristic to the circumference of point of inflection located outside an ordinary temperature range by adjustment of a primary coefficient, and adjusting said top-most-vertices temperature to an optimum value of an ordinary temperature range.

[Claim 2] A temperature characteristic adjustment method of a piezo-electric device which is the temperature characteristic adjustment method of a piezo-electric device which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further, and is characterized by adjusting the maximum point or the minimum point temperature of the temperature characteristic to an optimum value of an ordinary temperature range by adjusting said field internal version angle.

[Claim 3] It is the temperature characteristic adjustment method of a piezo-electric device which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further. It is considered that ST cut quartz plate which carried out the field internal version to the circumference of Z' shaft is the 3rd function temperature characteristic. The temperature characteristic is rotated to the circumference of point of inflection in which it is located in addition to ordinary temperature according adjustment of the temperature characteristic in an ordinary temperature range to adjustment of said field internal-version angle, and the maximum point or the minimum point of the temperature characteristic is seen. As a top-most-vertices temperature of the upper secondary function temperature characteristic A temperature characteristic adjustment method of a piezo-electric device characterized by adjusting to a proper value of an ordinary temperature range.

[Claim 4] Said ST cut quartz plate which carried out the field internal version to the circumference of Z' shaft is the temperature characteristic adjustment method of a piezo-electric device given in any 1 of

claims 1-3 characterized by being theta= 113 - 135 degrees and psi= 43**5 times in an Eulerian angle.
[Claim 5] Said ordinary temperature range is the temperature characteristic adjustment method of a piezo-electric device given in any 1 of claims 2-4 characterized by being set as -40-+85 degrees C.
[Claim 6] It is the temperature characteristic adjustment method of an oscillator circuit that a piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits was incorporated. While measuring the temperature characteristic of said piezo-electric device, measure the temperature characteristic of said oscillator circuit and it asks for those difference. See the maximum point which becomes the temperature characteristic required of said oscillator circuit of being located in the ordinary temperature range of said piezo-electric device so that vibrator temperature characteristic prediction may be carried out and it may become the prediction temperature characteristic concerned, or the minimum point temperature, and it is regarded as top-most-vertices temperature of the upper secondary function temperature characteristic. A temperature characteristic adjustment method of an oscillator circuit characterized by rotating the temperature characteristic to the circumference of point of inflection located outside an ordinary temperature range by adjustment of a primary coefficient, and adjusting said top-most-vertices temperature to an optimum value of an ordinary temperature range.
[Claim 7] A temperature characteristic adjustment method of an oscillator circuit characterized by constituting an oscillator circuit from a temperature requirement lower than point of inflection of the 3rd function temperature characteristic of a piezoelectric transducer which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further, seeing the maximum point or the minimum point temperature, and adjusting the frequency characteristic of an oscillator circuit as a top-most vertices temperature of the upper secondary function temperature characteristic.
[Claim 8] It is the temperature characteristic adjustment method of an oscillator circuit incorporating ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further. A temperature characteristic adjustment method of an oscillator circuit characterized by adjusting the temperature characteristic of said ST cut quartz plate which carried out the field internal version so that the temperature characteristic of an oscillator circuit incorporating the ST cut quartz plate concerned which carried out the field internal version to said ST cut quartz plate which carried out the field internal version might be searched for and both difference might be offset.
[Claim 9] A temperature characteristic adjustment method of an oscillator circuit according to claim 7 or 8 characterized by operating temperature limits of an oscillator circuit being -40-+85 degrees C.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the method of adjusting the temperature characteristic of the oscillator circuit in which the piezo-electric device and the temperature characteristic adjustment method of an oscillator circuit were started, especially a SAW device and this were carried.

[0002]

[Description of the Prior Art] Conventionally, the temperature characteristic (frequency-drift property over a temperature change) of a piezoelectric transducer has what is expressed with a secondary function like a tuning fork vibrator and a SAW resonator, and the thing expressed with the 3rd function like AT vibrator, as shown in drawing 9 .

[0003] In the frequency temperature characteristic of the oscillator circuit using this piezoelectric transducer, the oscillator-circuit temperature characteristic and the vibrator temperature characteristic are adjusted so that the temperature characteristic may become min focusing on 25 degrees C which is usually service temperature in operating temperature limits (-40-+85 degrees C). Usually, in an oscillator with a piezoelectric transducer with the secondary function temperature characteristic, if the top-most-vertices temperature of the oscillator-circuit temperature characteristic adjusts so that it may be located at the center of operating temperature limits, it will turn into the minimum temperature stability. In vibrator with the conventional secondary function temperature characteristic, the adjustment width of face of top-most-vertices temperature is per 40 degrees C from 0 degree C. On the other hand, since point-of-inflection temperature cannot be easily adjusted in AT cut vibrator with the 3rd function temperature characteristic, it is common to adjust primary coefficient terms so that the oscillator-circuit temperature characteristic of operating temperature limits may serve as the minimum width of face. In fact, with the piezoelectric transducer of the former secondary function temperature characteristic, it carries out by adjusting electrode layer thickness and width of face, and is performing adjusting the formation direction (X shaft orientations) of an electrode so that the point of inflection may be rotated as a center with vibrator with the latter 3rd function temperature characteristic.

[0004] By the way, when an oscillator circuit is constituted using the vibrator of the secondary function temperature characteristic, as shown in drawing 8 , generally the temperature characteristic of an oscillator circuit differs from the temperature characteristic of vibrator. The temperature characteristic seems to rotate to a clockwise rotation or a counterclockwise rotation. This is because the primary

coefficient of the temperature characteristic changes. Although change of this temperature characteristic includes not only change of a primary coefficient but change of a higher order coefficient, generally it can be represented with change of a primary coefficient. When making the frequency and the temperature characteristic of an oscillator into min, as mentioned above, generally the top-most-vertices temperature of the secondary function temperature characteristic is adjusted to the center of operating temperature limits. However, the adjustable range of the top-most-vertices temperature of vibrator is not free, and the range which can be adjusted is restricted.

[0005] On the other hand, when an oscillator circuit is constituted using the vibrator of the 3rd function temperature characteristic, generally the temperature characteristic of an oscillator circuit differs from the temperature characteristic of vibrator so that it may be shown drawing 7 . The temperature characteristic looks [rotate / to a clockwise rotation or a counterclockwise rotation] being the same as that of the case of a secondary property. In the case of the 3rd function temperature characteristic, migration of point-of-inflection temperature is difficult. Therefore, when making the frequency and the temperature characteristic of an oscillator into min, he is trying to acquire the minimum temperature characteristic in operating temperature limits by generally adjusting the primary coefficient of vibrator.

[0006]

[Problem(s) to be Solved by the Invention] By the way, when the operating temperature limits of an oscillator are unevenly distributed to the temperature characteristic adjustable range of vibrator and top-most-vertices temperature of the secondary function temperature characteristic cannot be especially set as the center of operating temperature limits, or when the point-of-inflection temperature of the 3rd function temperature characteristic has separated from the center of operating temperature limits, it is difficult to adjust so that the temperature characteristic may serve as the minimum temperature width of face in operating temperature limits. Moreover, a SAW resonator is usually the secondary function temperature characteristic, and has only a method of bringing top-most-vertices temperature to the center of operating temperature limits as the temperature characteristic improvement technique of an oscillator circuit.

[0007] This invention aims at offering the piezo-electric device which is operating temperature limits and can make the temperature characteristic of an oscillator circuit flatness more, and the temperature characteristic adjustment method of an oscillator circuit by using the property of a temperature region lower than the point of inflection of the vibrator of the 3rd function temperature characteristic.

[0008]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, a temperature characteristic adjustment method of a piezo-electric device concerning this invention was constituted as follows. That is, it was the temperature characteristic adjustment method of the piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits, the maximum point or the minimum point temperature located in an ordinary-temperature range saw, and it regarded as the top-most-vertices temperature of the upper secondary function temperature characteristic, and it constituted so that the temperature characteristic rotates to the circumference of point of inflection located outside an ordinary-temperature range by adjustment of a primary coefficient and said top-most-vertices temperature may adjust to an optimum value of an ordinary-temperature range.

[0009] Moreover, this invention is the temperature characteristic adjustment method of a piezo-electric

device which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is make to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtain to the circumference of Z' shaft further, and by adjust said field internal version angle, it can also be constitute so that the maximum point or the minimum point temperature of the temperature characteristic may be adjust to an optimum value of an ordinary temperature range.

[0010] Furthermore, this invention is the temperature characteristic adjustment method of a piezo-electric device which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further. It is considered that ST cut quartz plate which carried out the field internal version to the circumference of Z' shaft is the 3rd function temperature characteristic. It is characterized by rotating the temperature characteristic to the circumference of point of inflection in which it is located in addition to ordinary temperature according adjustment of the temperature characteristic in an ordinary temperature range to adjustment of said field internal-version angle, seeing the maximum point or the minimum point of the temperature characteristic, and making it a proper value of an ordinary temperature range as a top-most-vertices temperature of the upper secondary function temperature characteristic.

[0011] In the above-mentioned configuration, said ST cut quartz plates which carried out the field internal version to the circumference of Z' shaft are theta= 113 - 135 degrees and psi= 43**5 times in an Eulerian angle. Moreover, said ordinary temperature range is set as -40-+80 degrees C.

[0012] A temperature characteristic adjustment method of an oscillator circuit concerning this invention It is the temperature characteristic adjustment method of an oscillator circuit that a piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits was incorporated. While measuring the temperature characteristic of said piezo-electric device, measure the temperature characteristic of said oscillator circuit and it asks for those difference. See the maximum point which becomes the temperature characteristic required of said oscillator circuit of being located in the ordinary temperature range of said piezo-electric device so that vibrator temperature characteristic prediction may be carried out and it may become the prediction temperature characteristic concerned, or the minimum point temperature, and it is regarded as top-most-vertices temperature of the upper secondary function temperature characteristic. It is characterized by rotating the temperature characteristic to the circumference of point of inflection located outside an ordinary temperature range by adjustment of a primary coefficient, and adjusting said top-most-vertices temperature to an optimum value of an ordinary temperature range.

[0013] Moreover, the temperature characteristic adjustment method of an oscillator circuit concerning this invention constitutes an oscillator circuit from a temperature requirement lower than point of inflection of the 3rd function temperature characteristic of a piezoelectric transducer which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further, and it constitutes it so that the maximum point or the minimum point temperature may be seen and the frequency characteristic of an oscillator circuit may be adjusted as a top-most-vertices temperature of the upper secondary function temperature characteristic.

[0014] Moreover, this invention is the temperature characteristic adjustment method of an oscillator

circuit incorporating ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is made to rotate a quartz plate to the circumference of an electrical axis (X-axis), and is obtained to the circumference of Z' shaft further. It is good also as a configuration which adjusts the temperature characteristic of said ST cut quartz plate which carried out the field internal version so that the temperature characteristic of an oscillator circuit incorporating the ST cut quartz plate concerned which carried out the field internal version to said ST cut quartz plate which carried out the field internal version might be searched for and both difference might be offset. In this case, operating temperature limits of an oscillator circuit are -40-+85 degrees C.

[0015]

[Embodiment of the Invention] The concrete operation gestalt of the piezo-electric device concerning this invention and the temperature characteristic adjustment method of an oscillator circuit is explained to it at details, referring to a drawing to below. Generally, at a SAW resonator, although the secondary function temperature characteristic is common, a piezoelectric transducer with the 3rd function temperature characteristic is used, it is located in the temperature field where point-of-inflection temperature is higher than operating temperature limits (or low), and the oscillator temperature characteristic with small temperature-change width of face can be realized by adjusting the oscillator-circuit temperature characteristic as operating temperature limits using the temperature characteristic near the maximum point of the 3rd function temperature characteristic.

[0016] For example, when cutting down a piezoelectric transducer from Xtal, the temperature characteristic changes according to the direction of a cut. Although the crystallographic axis of Xtal is defined by an electrical axis (X-axis), a machine shaft (Y-axis), and the optical axis (Z-axis) as shown in drawing 1 What is called ST cut is started in accordance with the crystallographic axis (X, Y', Z') from the quartz plate 1 with which an Eulerian angle (phi, theta, psi) rotates Xtal Z disc 2 of (0, 0, 0) theta= 113 to 135 degrees to the circumference of an electrical axis (X-axis), and is acquired. the piezoelectric transducer produced so that it might be made to rotate psi= 43**5 times further to the circumference of Z' shaft of this ST cut quartz plate 1 and the propagation of a surface acoustic wave might turn into the direction of this psi -- Z' -- it is called ST cut quartz resonator 3 which carried out the field internal version to the circumference of a shaft. This field internal-version ST cut quartz resonator 3 has small frequency rate of change, and its temperature characteristic is very good. And it was thought that it was a kind of ST cut and the temperature characteristic was the secondary function temperature characteristic. However, when the artificer etc. investigated, it became clear that it was the 3rd function temperature characteristic which has point of inflection in nearly 110 degrees in practice. Since inspecting the temperature characteristic in such a temperature field might damage other elements which constitute an oscillator when having separated from the operating temperature limits where point of inflection is actual, it was impossible to have checked existence of point of inflection in practice. Therefore, when it was going to adjust the temperature characteristic of the vibrator cut down from this ST cut quartz plate that carried out the field internal version to the circumference of Z' shaft, adjustment became very difficult even if carried out as the secondary function temperature characteristic.

[0017] with this operation gestalt, the knowledge that ST cut quartz resonator which carried out a field internal version to the circumference of Z' shaft be the 3rd function temperature characteristic acquire, the maximum point or the minimum point temperature locate in an ordinary temperature range see, and it regard as the top-most vertices temperature of the upper secondary function temperature characteristic,

and it constitute so that the temperature characteristic rotate to the circumference of the point of inflection locate outside an ordinary temperature range by adjustment of a primary coefficient term and said top-most vertices temperature may adjust to the optimum value of an ordinary temperature range. By adjusting said field internal-version angle of the piezo-electric device which consists of an ST cut quartz plate which carried out the field internal version of the ST cut quartz plate which is make to rotate a quartz plate theta= 113 to 135 degrees to the circumference of an electrical axis (X-axis), and is obtain to the circumference of Z' shaft only psi= 43**5 times further, this adjusts the maximum point or the minimum point temperature of the temperature characteristic to the optimum value of an ordinary temperature range, and, specifically, adjusted the temperature characteristic.

[0018] Now, since point-of-inflection temperature is about 110 degrees C and a common temperature requirement is -40-+85 degrees C of temperature fields lower than it, the temperature characteristic of ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft uses the property field which has the maximum point of being located in a temperature field lower than point of inflection, as shown in drawing 2 (portion enclosed with having been square in drawing 2). Since it is difficult to move point of inflection in the case of the 3rd function temperature characteristic, a primary coefficient term is adjusted and a characteristic ray is rotated to the circumference of point of inflection. By this, the characteristic ray in a common service temperature field is seen, and it regards as the upper secondary function temperature characteristic, and the maximum point is adjusted so that it may be located at the center of a service temperature field as a top-most-vertices temperature of the secondary function temperature characteristic. When the continuous line shown in drawing 2 is a basic characteristic ray, this obtains a characteristic ray as made rotate a characteristic ray to the circumference of point of inflection and newly shown with the dashed line so that the maximum point P1 may be located in the center of operating temperature limits Tz. Thereby, the maximum point temperature can move to P1 ->P2, and can make frequency rate of change min in operating temperature limits as if it carried out the parallel displacement of the top-most-vertices temperature in operating temperature limits.

[0019] The piezoelectric transducer of ST cut which carried out the field internal version to the circumference of Z' shaft produces ST cut Xtal wafer first, gives psi whenever [field interior angle] using the orienteering flat, and carries out exposure formation of a reflector film and the blind-like electrode layer to each vibrator field at this. By carrying out degree adjustment of the psi= 43 degrees whenever [above-mentioned field interior angle], the practical tuning of this 3rd function temperature characteristic changes the propagation of a surface acoustic wave, and performs it. Since the relation between the change direction of psi and the hand of cut of a characteristic ray is known beforehand, the adjustment direction and the amount of adjustments can be predicted to some extent. Therefore, the piezoelectric transducer of ST cut which carried out the field internal version to the circumference of Z' shaft is created, that temperature characteristic is searched for, the rotation of a characteristic ray is calculated so that the maximum point or the minimum point may be located at the center in the operating temperature limits by the design specification, and it asks for the degree adjustment angle alpha of psi corresponding to this rotation. The orienteering flat corresponding to psi is set as angle psi**alpha whenever [original field interior angle], and a reflector film and a blind-like electrode layer are formed. The piezo-electric device of ST cut which carried out the field internal version to the circumference of Z' shaft which makes frequency rate of change min in operating temperature limits by this can be obtained.

[0020] By the way, the outline configuration of the oscillator circuit 10 incorporating ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft mentioned above is shown in drawing 3 . It is the example of a configuration which connected amplifier 16 to juxtaposition in the series circuit of a piezoelectric transducer 12 and the phase machine 14. As for the temperature characteristic of this oscillator circuit 10, the temperature characteristic of vibrator 12 and the temperature characteristic of a circuit 10 were added. Drawing 4 (1) shows the quartz-resonator independent temperature characteristic of ST cut which carried out the field internal version to the circumference of Z' shaft, and this drawing (2) shows the temperature characteristic of the oscillator circuit incorporating this vibrator. This drawing (2) shows what the temperature characteristic of vibrator rotated clockwise. In an oscillator circuit, since this rotation breaks out, this is foreseen, and it adjusts so that the temperature characteristic in operating temperature limits may become flat. In this case, seemingly, the temperature characteristic of an oscillator circuit adjusts the temperature characteristic of vibrator in operating temperature limits so that top-most-vertices temperature may come to the center of operating temperature limits. That is, if a piezoelectric transducer 12 is independent, the 3rd function temperature characteristic as shown in drawing 4 (1) is shown, and seemingly, the temperature characteristic of an oscillator circuit when this is included in an oscillator circuit 10 shows the modality which the temperature characteristic rotated to the circumference of point of inflection, as shown in drawing 4 (2). Then, as a property is shown to drawing 4 (3) by the temperature requirement used as an oscillator circuit 10, it determines that the temperature characteristic of an oscillator circuit which becomes flat will become drawing 4 (2), and it counts backward, and the temperature characteristic of a piezoelectric transducer 12 is adjusted like drawing 4 (1). The property which specifically subtracted the temperature characteristic of an oscillator circuit from the property for which it asks turns into the temperature characteristic of vibrator. This temperature characteristic is expressed with the 3rd function which has point-of-inflection temperature in a temperature region higher than operating temperature limits.

[0021] Moreover, in the case of different operating temperature limits, the temperature characteristic as an oscillator circuit is foreseen and adjusted similarly. The enlarged view (this drawing (3)) in the temperature characteristic (this drawing (2)) when including in drawing 5 in the piezoelectric transducer independent temperature characteristic (this drawing (1)) and an oscillator circuit and operating temperature limits is shown. In this case, although an apparent top-most-vertices temperature is adjusted to the center of operating temperature limits, it can realize by adjusting the coefficient of the 3rd function of vibrator, and this can control a property easily rather than adjustment of the top-most-vertices temperature of a secondary function, and adjustment of the point-of-inflection temperature of the 3rd function.

[0022] The concrete procedure of the temperature characteristic adjustment method when building into such an oscillator circuit 10 ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft is shown in the flow chart of drawing 6 . If it goes into temperature characteristic tuning (step 100), the aim temperature characteristic will be first set up from the demand characteristics of an oscillator (step 102). They are operating temperature limits and allowable frequency deviation. and ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft incorporated -- the difference of the independent temperature characteristic and the temperature characteristic as an oscillator -- it is confirmed whether there is any data (step 104). difference -- if there

is no data, the temperature characteristic of vibrator will be measured first (step 106). And the vibrator concerned is built into the actually used oscillator (step 108), and the temperature characteristic as an oscillator is measured shortly (step 110). and the difference of both temperature characteristic -- calculating (step 112) -- the difference from an aim property -- the temperature characteristic which deducts data and is required of vibrator is predicted (step 114). What is necessary is to create a normal vibration child so to speak, and just to create at theta= 123 degrees and psi= 43 degrees according to an Eulerian angle in step 106. And the amount of modification of psi is determined whenever [for considering as the temperature characteristic demanded at step 114 / field interior angle], and the vibrator which changed the propagation of a surface acoustic wave is made as an experiment (step 116). And in order to adjust the temperature characteristic of vibrator to desired property orientation and to check **, the temperature characteristic is measured (step 118), subsequently to an oscillator vibrator is incorporated (step 120), and the temperature characteristic of an oscillator is measured (step 122). If this regards demand characteristics, vibrator will be created on the conditions made as an experiment at step 116. If it seems that a demand is not satisfied (step 124), a series of activities will be repeated until it changes psi into step 112 whenever [return and field interior angle] and is satisfied with it of demand characteristics.

[0023] Thus, according to this operation gestalt, by combining the vibrator temperature characteristic and the oscillator temperature characteristic, the maximum point of vibrator is used as a top-most-vertices temperature of operating temperature limits, and the oscillator temperature characteristic can be adjusted so that the temperature characteristic may serve as min in operating temperature limits. The temperature characteristic of the whole oscillator is improvable because the temperature characteristic of amplifier and a phase shifter makes the property that the temperature characteristic of vibrator and the different temperature characteristic are shown in operating temperature limits, and the temperature characteristic of vibrator can be improved.

[0024] In this case, the temperature characteristic of vibrator is a false secondary property in operating temperature limits, the temperature characteristic of vibrator is the 3rd function temperature characteristic, point-of-inflection temperature is in the temperature region higher than the center or the low temperature requirement of operating temperature limits, and the vibrator which is visible to a false secondary property [in operating temperature limits] is used.

[0025] Although the above-mentioned operation gestalt shows the example using ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft, the temperature characteristic of vibrator can apply a cut which has point of inflection in a temperature field lower than operating temperature limits to the vibrator in which a false secondary property is shown in operating temperature limits.

[0026]

[Effect of the Invention] As explained above, this invention is the temperature characteristic adjustment method of the piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits. See the maximum point or the minimum point temperature located in an ordinary temperature range, and it is regarded as the top-most-vertices temperature of the upper secondary function temperature characteristic. Rotate the temperature characteristic to the circumference of the point of inflection located outside an ordinary temperature range by adjustment of a primary coefficient, and said

top-most-vertices temperature is adjusted to the optimum value of an ordinary temperature range. Moreover, it is the temperature characteristic adjustment method of an oscillator circuit that the piezo-electric device which has the 3rd function temperature characteristic and usually has the point of inflection of said 3rd function temperature characteristic outside operating temperature limits was incorporated. While measuring the temperature characteristic of said piezo-electric device, measure the temperature characteristic of said oscillator circuit and it asks for those difference. See the maximum point which becomes the temperature characteristic required of said oscillator circuit of being located in the ordinary temperature range of said piezo-electric device so that vibrator temperature characteristic prediction may be carried out and it may become the prediction temperature characteristic concerned, or the minimum point temperature, and it is regarded as the top-most-vertices temperature of the upper secondary function temperature characteristic. Since it constituted so that the temperature characteristic might be rotated to the circumference of the point of inflection located outside an ordinary temperature range by adjustment of a primary coefficient and said top-most-vertices temperature might be adjusted to the optimum value of an ordinary temperature range By using the property of a temperature region lower than the point of inflection of the vibrator of the 3rd function temperature characteristic, the temperature characteristic of an oscillator circuit can be made more into flatness in operating temperature limits.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is explanatory drawing of ST cut Xtal which carried out the field internal version to the circumference of Z' shaft.
[Drawing 2] It is the temperature characteristic diagram of ST cut quartz resonator which carried out the field internal version to the circumference of Z' shaft.
[Drawing 3] It is the example of a configuration of an oscillator circuit.
[Drawing 4] They are a temperature characteristic diagram when including in an oscillator at the piezoelectric transducer list concerning an operation gestalt, and its partial enlarged view.
[Drawing 5] They are a temperature characteristic diagram when including in an oscillator at the piezoelectric transducer list concerning other operation gestalten, and its partial enlarged view.
[Drawing 6] It is the flow chart which shows the tuning of the oscillator temperature characteristic.
[Drawing 7] It is explanatory drawing of the tuning of the 3rd function temperature characteristic.
[Drawing 8] It is explanatory drawing of the tuning of the secondary function temperature characteristic.
[Drawing 9] It is explanatory drawing of the conventional secondary function temperature characteristic and the 3rd function temperature characteristic.
[Description of Notations]
1 [... An oscillator, 12 / ... A piezoelectric transducer, 14 / ... A phase machine, 16 / ... Amplifier.] ...... ST cut quartz plate, 2 ... The Xtal Z disc, 3 ... ST cut quartz resonator, 10 which carried out the field internal version to the circumference of Z' shaft

---

[Translation done.]

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号
特開2003－32045
（P2003－32045A）
(43)公開日　平成15年１月31日(2003.1.31)

(51)Int.Cl.⁷	識別記号	ＦＩ	テーマコード゛(参考)
Ｈ０３Ｂ　5/32		Ｈ０３Ｂ　5/32	Ｚ　５Ｊ０７９
Ｈ０３Ｈ　3/04		Ｈ０３Ｈ　3/04	Ｃ

審査請求　未請求　請求項の数９　ＯＬ　（全 ８ 頁）

(21)出願番号　特願2001－217238(P2001－217238)

(22)出願日　平成13年７月17日(2001.7.17)

(71)出願人　000002369
セイコーエプソン株式会社
東京都新宿区西新宿２丁目４番１号

(72)発明者　小林　祥宏
長野県諏訪市大和３丁目３番５号　セイコーエプソン株式会社内

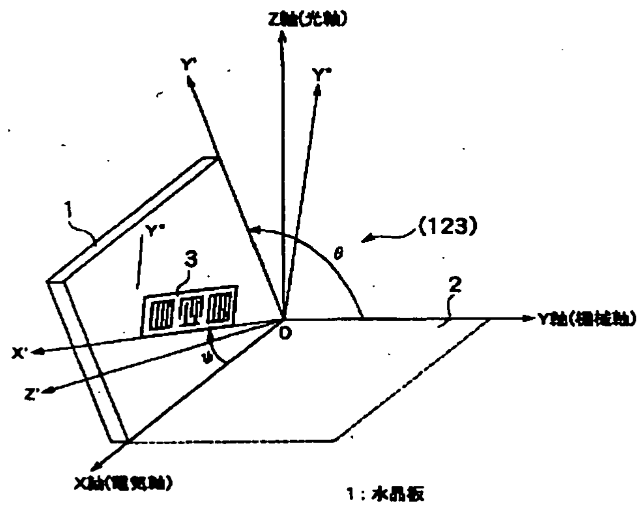
(72)発明者　今井　信行
長野県諏訪市大和３丁目３番５号　セイコーエプソン株式会社内

(74)代理人　100095728
弁理士　上柳　雅誉　（外２名）

Ｆターム(参考)　5J079 AA04 AA06 BA02 DB05

(54)【発明の名称】　圧電デバイスおよび発振回路の温度特性調整方法

(57)【要約】
【課題】　３次関数温度特性の振動子の変曲点より低い温度域の特性を使うことにより、発振回路の温度特性を使用温度範囲で、より平坦にすることのできる圧電デバイスおよび発振回路の温度特性調整方法を得る。
【解決手段】３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイス並びに発振回路の温度特性調整方法である。常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整する。



1：水晶板
2：水晶Z板
3：弾性表面波素子
ψ：面内回転軸

1

【特許請求の範囲】

【請求項1】　３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスの温度特性調整方法であって、

常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整することを特徴とする圧電デバイスの温度特性調整方法。

【請求項2】　水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板からなる圧電デバイスの温度特性調整方法であって、

前記面内回転角を調整することによって温度特性の極大点もしくは極小点温度を常温範囲の最適値に調整することを特徴とする圧電デバイスの温度特性調整方法。

【請求項3】　水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板からなる圧電デバイスの温度特性調整方法であって、

Ｚ’軸回りに面内回転させたＳＴカット水晶板を３次関数温度特性とみなして常温範囲での温度特性の調整を前記面内回転角の調整による常温以外に位置する変曲点回りに温度特性を回転させて温度特性の極大点もしくは極小点を見掛け上の２次関数温度特性の頂点温度として常温範囲の適正値に調整することを特徴とする圧電デバイスの温度特性調整方法。

【請求項4】　Ｚ’軸回りに面内回転させた前記ＳＴカット水晶板は、オイラー角においてθ＝１１３度～１３５度，Ψ＝４３±５度であることを特徴とする請求項１～３のいずれか１に記載の圧電デバイスの温度特性調整方法。

【請求項5】　前記常温範囲は－４０～＋８５℃に設定されていることを特徴とする請求項２～４のいずれか１に記載の圧電デバイスの温度特性調整方法。

【請求項6】　３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスが組み込まれた発振回路の温度特性調整方法であって、

前記圧電デバイスの温度特性を測定すると共に前記発振回路の温度特性を測定してそれらの差分を求め、前記発振回路に要求される温度特性になる振動子温度特性予測し、当該予測温度特性となるように前記圧電デバイスの常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整することを特徴とする発振回路の温度特性調整方法。

【請求項7】　水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回

2

転させたＳＴカット水晶板からなる圧電振動子の３次関数温度特性の変曲点より低い温度範囲で発振回路を構成し、極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度として発振回路の周波数特性を調整することを特徴とする発振回路の温度特性調整方法。

【請求項8】　水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板を組み込んだ発振回路の温度特性調整方法であって、面内回転させた前記ＳＴカット水晶板と面内回転させた当該ＳＴカット水晶板を組み込んだ発振回路の温度特性を求め、両者の差分が相殺されるように面内回転させた前記ＳＴカット水晶板の温度特性を調整することを特徴とする発振回路の温度特性調整方法。

【請求項9】　発振回路の使用温度範囲が－４０～＋８５℃であることを特徴とする請求項７または８記載の発振回路の温度特性調整方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は圧電デバイスおよび発振回路の温度特性調整方法に係り、特にＳＡＷデバイスとこれを搭載した発振回路の温度特性を調整する方法に関する。

【０００２】

【従来の技術】従来、圧電振動子の温度特性（温度変化に対する周波数変動特性）は、図９に示すように、音叉振動子、ＳＡＷ共振子などのように２次関数で表されるものや、ＡＴ振動子などのように３次関数で表されるものがある。

【０００３】この圧電振動子を用いた発振回路の周波数温度特性では、通常使用温度である２５℃を中心に使用温度範囲（－４０～＋８５℃）で温度特性が最小になるように発振回路温度特性と振動子温度特性を調整している。通常、２次関数温度特性をもつ圧電振動子を持つ発振器では、発振回路温度特性の頂点温度が使用温度範囲の中心に位置するように調整すると最小の温度安定度となる。従来の２次関数温度特性をもつ振動子では頂点温度の調整幅は０℃から４０℃あたりである。これに対し、３次関数温度特性をもつＡＴカット振動子などでは変曲点温度を容易に調整できないので、使用温度範囲の発振回路温度特性が最小幅となるように１次係数項を調整するのが一般的である。実際には、前者の２次関数温度特性の圧電振動子では電極膜厚や幅を調整することで行い、後者の３次関数温度特性をもつ振動子では、その変曲点を中心として回転するように電極の形成方向（Ｘ軸方向）を調整することを行っている。

【０００４】ところで、２次関数温度特性の振動子を用いて発振回路を構成した場合、図８に示すように、発振回路の温度特性が振動子の温度特性と一般的に異なる。温度特性が時計方向あるいは反時計方向に回転するよう

に見える。これは、温度特性の１次係数が変化することによる。この温度特性の変化は、１次係数の変化だけでなく、より高次の係数の変化も含んでいるが、一般的には一次係数の変化で代表できる。発振器の周波数・温度特性を最小にする場合、上述したように、一般的には２次関数温度特性の頂点温度を使用温度範囲の中心に調整する。しかし、振動子の頂点温度の調整範囲は自由ではなく、調整できる範囲が限られている。

【０００５】一方、３次関数温度特性の振動子を用いて発振回路を構成した場合、図７示すように、発振回路の温度特性が振動子の温度特性と一般的に異なる。２次特性の場合と同様に、温度特性が時計方向あるいは反時計方向に回転するように見える。３次関数温度特性の場合、変曲点温度の移動は難しい。したがって、発振器の周波数・温度特性を最小にする場合、一般的には振動子の１次係数を調整することによって、使用温度範囲での最小温度特性を得るようにしている。

【０００６】

【発明が解決しようとする課題】ところで、振動子の温度特性調整範囲に対し、発振器の使用温度範囲が偏在しているような場合、特に２次関数温度特性の頂点温度を使用温度範囲の中心に設定できないような場合、あるいは、３次関数温度特性の変曲点温度が使用温度範囲の中心から外れている場合は、温度特性が使用温度範囲において最小温度幅となるように調整することは難しい。また、ＳＡＷ共振子は通常２次関数温度特性であり、発振回路の温度特性改善手法としては、頂点温度を使用温度範囲の中心に持ってくる方法しかない。

【０００７】本発明は、３次関数温度特性の振動子の変曲点より低い温度域の特性を使うことにより、発振回路の温度特性を使用温度範囲で、より平坦にすることのできる圧電デバイスおよび発振回路の温度特性調整方法を提供することを目的とする。

【０００８】

【課題を解決するための手段】上記目的を達成するために、本発明に係る圧電デバイスの温度特性調整方法は次のように構成した。すなわち、３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスの温度特性調整方法であって、常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整するように構成した。

【０００９】また、本発明は、水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板からなる圧電デバイスの温度特性調整方法であって、前記面内回転角を調整することによって温度特性の極大点もしくは極小点温度を常温範囲の最適値に調整するように構成することもできる。

【００１０】更に、本発明は、水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板からなる圧電デバイスの温度特性調整方法であって、Ｚ’軸回りに面内回転させたＳＴカット水晶板を３次関数温度特性とみなして常温範囲での温度特性の調整を前記面内回転角の調整による常温以外に位置する変曲点回りに温度特性を回転させて温度特性の極大点もしくは極小点を見掛け上の２次関数温度特性の頂点温度として常温範囲の適正値にすることを特徴とする。

【００１１】上記構成において、Ｚ’軸回りに面内回転させた前記ＳＴカット水晶板は、オイラー角においてθ＝１１３度～１３５度，Ψ＝４３±５度である。また、前記常温範囲は－４０～＋８０℃に設定されている。

【００１２】本発明に係る発振回路の温度特性調整方法は、３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスが組み込まれた発振回路の温度特性調整方法であって、前記圧電デバイスの温度特性を測定すると共に前記発振回路の温度特性を測定してそれらの差分を求め、前記発振回路に要求される温度特性になる振動子温度特性予測し、当該予測温度特性となるように前記圧電デバイスの常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整することを特徴とする。

【００１３】また、本発明に係る発振回路の温度特性調整方法は、水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板からなる圧電振動子の３次関数温度特性の変曲点より低い温度範囲で発振回路を構成し、極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度として発振回路の周波数特性を調整するように構成している。

【００１４】また、本発明は、水晶板を電気軸（Ｘ軸）回りに回転させて得られるＳＴカット水晶板を更にＺ’軸回りに面内回転させたＳＴカット水晶板を組み込んだ発振回路の温度特性調整方法であって、面内回転させた前記ＳＴカット水晶板と面内回転させた当該ＳＴカット水晶板を組み込んだ発振回路の温度特性を求め、両者の差分が相殺されるように面内回転させた前記ＳＴカット水晶板の温度特性を調整する構成としてもよい。この場合において、発振回路の使用温度範囲が－４０～＋８５℃である。

【００１５】

【発明の実施の形態】以下に、本発明に係る圧電デバイスおよび発振回路の温度特性調整方法の具体的実施形態を、図面を参照しつつ、詳細に説明する。一般に、ＳＡ

W共振子では、2次関数温度特性が一般的であるが、3次関数温度特性をもつ圧電振動子を使用して、変曲点温度が使用温度範囲よりも高い（または低い）温度領域に位置し、3次関数温度特性の極大点付近の温度特性を使用温度範囲として使用して発振回路温度特性を調節することで、温度変化幅が小さい発振器温度特性を実現することができる。

【0016】例えば、圧電振動子を水晶から切り出す場合、カットの方向によって温度特性が変わる。図1に示すように、水晶の結晶軸は、電気軸（X軸）、機械軸（Y軸）、光軸（Z軸）によって定義されるが、STカットといわれるものはオイラー角（φ、θ、Ψ）が（0、0、0）の水晶Z板2を、電気軸（X軸）周りにθ＝113〜135度回転させて得られる水晶板1からその結晶軸（X，Y’，Z’）に沿って切り出されるものである。このSTカット水晶板1のZ’軸周りにさらにΨ＝43±5度回転させ、弾性表面波の伝播方向がこのΨの方向となるように作製された圧電振動子がZ’軸回りに面内回転させたSTカット水晶振動子3といわれるものである。この面内回転STカット水晶振動子3は、周波数変化率が小さくて温度特性が極めてよい。そしてSTカットの一種であり、その温度特性は2次関数温度特性であると思われていた。しかし、発明者等が調べてみると、実際は変曲点が110度近辺にある3次関数温度特性であることが判明した。変曲点が実際の使用温度範囲から外れている場合には、そのような温度領域で温度特性を検査することは発振器を構成する他の素子を破損してしまう可能性があるので、実際上は変曲点の存在を確認することが不可能であった。したがって、Z’軸回りに面内回転させたこのSTカット水晶板から切り出された振動子の温度特性を調整しようとする場合、2次関数温度特性として行っても調整が極めて困難なものとなっていたのである。

【0017】本実施形態では、Z’軸回りに面内回転させたSTカット水晶振動子が3次関数温度特性であるとの知見を得て、常温範囲に位置する極大点もしくは極小点温度を見掛け上の2次関数温度特性の頂点温度とみなし、一次係数項の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整するように構成したものである。これは具体的には、水晶板を電気軸（X軸）回りにθ＝113〜135度回転させて得られるSTカット水晶板を更にZ’軸回りにΨ＝43±5度だけ面内回転させたSTカット水晶板からなる圧電デバイスの前記面内回転角を調整することによって温度特性の極大点もしくは極小点温度を常温範囲の最適値に調整して温度特性を調整するようにした。

【0018】今、図2に示しているように、Z’軸回りに面内回転させたSTカット水晶振動子の温度特性は変曲点温度が約110℃であり、常用温度範囲は、それより低い温度領域－40〜＋85℃であるので、変曲点より低い温度領域に位置する極大点を有する特性領域を使用する（図2において四角で囲んだ部分）。3次関数温度特性の場合には変曲点を移動することが困難であるので，一次係数項を調整し、特性線を変曲点周りに回転させる。これによって、常用使用温度領域での特性線を見かけ上の2次関数温度特性として捉え，極大点を2次関数温度特性の頂点温度として使用温度領域の中心に位置するように調整するのである。これは、図2に示す実線が基本特性線である場合、その極大点P_1を使用温度範囲T_zの中央に位置するように、特性線を変曲点周りに回転させて新たに破線で示しているような特性線を得る。これにより、使用温度範囲であたかも頂点温度を平行移動したかの如く、極大点温度が$P_1 \rightarrow P_2$に移動し、使用温度範囲において周波数変化率を最小にすることができる。

【0019】Z’軸回りに面内回転させたSTカットの圧電振動子は、まずSTカット水晶ウェハを作製し，そのオリエンテーリングフラットを利用して面内角度Ψを与え、これに各振動子領域に反射電極膜とすだれ状電極膜を露光形成するのである。この3次関数温度特性の実際的調整作業は、上記面内角度Ψ＝43度を加減調整することによって弾性表面波の伝播方向を変えて行う。Ψの変化方向と特性線の回転方向の関係は予め分かっているので、調整方向と調整量はある程度予測できる。したがって、Z’軸回りに面内回転させたSTカットの圧電振動子を作成してその温度特性を求め、設計仕様による使用温度範囲で極大点もしくは極小点が中心に位置するように特性線の回転量を求め、この回転量に対応するΨの加減調整角度αを求める。当初の面内角度Ψに対応するオリエンテーリングフラットを角度Ψ±αに設定して反射電極膜とすだれ状電極膜を形成するのである。これにより使用温度範囲において周波数変化率を最小にするZ’軸回りに面内回転させたSTカットの圧電デバイスを得ることができる。

【0020】ところで、上述したZ’軸回りに面内回転させたSTカット水晶振動子を組み込んだ発振回路10の概略構成を図3に示す。圧電振動子12、位相器14の直列回路に増幅器16を並列に接続した構成例である。この発振回路10の温度特性は、振動子12の温度特性と回路10の温度特性が加算されたものになる。図4（1）はZ’軸回りに面内回転させたSTカットの水晶振動子単独の温度特性を示し，同図（2）はこの振動子を組み込んだ発振回路の温度特性を示している。同図（2）は振動子の温度特性が時計回りに回転したものを示す。発振回路では、この回転が起きるので、これを見越して、使用温度範囲における温度特性が平坦になるように調整する。この場合、発振回路の温度特性が使用温度範囲で見掛け上、頂点温度が使用温度範囲の中心にくるように、振動子の温度特性を調整する。すなわち、圧

電振動子１２が単独では図４（１）に示すような３次関数温度特性を示し、これが発振回路１０に組み込まれたときの発振回路の温度特性は見掛け上、図４（２）に示すように温度特性が変曲点回りに回転した様相を示す。そこで、発振回路１０として使用する温度範囲で特性が図４（３）に示される如く平坦となるような発振回路の温度特性を図４（２）となるように決定し、逆算して圧電振動子１２の温度特性を図４（１）のように調整するのである。具体的には、所望する特性から発振回路の温度特性を引き算した特性が振動子の温度特性となる。この温度特性は変曲点温度が使用温度範囲より高い温度域にある３次関数で表される。

【００２１】また、異なる使用温度範囲の場合には、同様に、発振回路としての温度特性を見越して調整する。図５に圧電振動子単独の温度特性（同図（１））、発振回路に組み込んだときの温度特性（同図（２））、使用温度範囲における拡大図（同図（３））を示している。この場合には、見掛け上の頂点温度を使用温度範囲の中心に調整するが、これは振動子の３次関数の係数を調整することで実現でき、２次関数の頂点温度の調整、及び３次関数の変曲点温度の調整よりも容易に特性をコントロールすることができる。

【００２２】このような発振回路１０にＺ’軸回りに面内回転させたＳＴカット水晶振動子を組み込んだときの温度特性調整方法の具体的手順を図６のフローチャートに示す。温度特性調整作業に入ると（ステップ１００）、最初に発振器の要求特性から目標温度特性が設定される（ステップ１０２）。使用温度範囲と許容周波数偏差である。そして、組み込まれるＺ’軸回りに面内回転させたＳＴカット水晶振動子単独の温度特性と、発振器としての温度特性の差分データがあるかどうかがチェックされる（ステップ１０４）。差分データがなければ、最初に振動子の温度特性を測定する（ステップ１０６）。そして、実際に使用する発振器に当該振動子を組み込み（ステップ１０８）、今度は発振器としての温度特性を測定する（ステップ１１０）。そして、両者の温度特性の差分を演算し（ステップ１１２）、目標特性から差分データを差し引いて振動子に要求される温度特性を予測する（ステップ１１４）。ステップ１０６ではいわば基準振動子を作成するもので、例えば、オイラー角でθ＝１２３度、Ψ＝４３度で作成すればよい。そして、ステップ１１４で要請される温度特性とするための面内角度Ψの変更量を決定し、弾性表面波の伝播方向を変更した振動子を試作する（ステップ１１６）。そして、振動子の温度特性が所望の特性傾向に調整されたを確認するために温度特性が測定され（ステップ１１８）、次いで振動子を発振器に組み込んで（ステップ１２０）、発振器の温度特性を測定する（ステップ１２２）。これが要求特性を見なすものであれば、ステップ１１６で試作された条件で振動子を作成する。要求を充足しないようであれば（ステップ１２４）、ステップ１１２に戻り、面内角度Ψを変更して要求特性を満足するまで一連の作業を繰り返すのである。

【００２３】このように、本実施形態によれば、振動子温度特性と発振器温度特性を組み合わせることによって、振動子の極大点を使用温度範囲の頂点温度として利用し、使用温度範囲で温度特性が最小となるように発振器温度特性を調整できる。増幅器及び移相器の温度特性が使用温度範囲において振動子の温度特性と異なる温度特性を示し、振動子の温度特性を改善できる特性を作り込むことで、発振器全体の温度特性を改善できる。

【００２４】この場合、振動子の温度特性が使用温度範囲において擬似的な２次特性であり、振動子の温度特性が３次関数温度特性であり、変曲点温度が使用温度範囲の中心より高い温度域または低い温度範囲にあり、使用温度範囲では擬似的な２次特性に見える振動子を用いている。

【００２５】上記実施形態ではＺ’軸回りに面内回転させたＳＴカット水晶振動子を用いた例を示しているが、変曲点が使用温度範囲より低い温度領域にあるようなカットなど、振動子の温度特性が使用温度範囲において擬似的な２次特性を示す振動子に適用できる。

【００２６】

【発明の効果】以上説明したように、本発明は３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスの温度特性調整方法であって、常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整するようにし、また、３次関数温度特性を有し前記３次関数温度特性の変曲点が通常使用温度範囲外にある圧電デバイスが組み込まれた発振回路の温度特性調整方法であって、前記圧電デバイスの温度特性を測定すると共に前記発振回路の温度特性を測定してそれらの差分を求め、前記発振回路に要求される温度特性になる振動子温度特性予測し、当該予測温度特性となるように前記圧電デバイスの常温範囲に位置する極大点もしくは極小点温度を見掛け上の２次関数温度特性の頂点温度とみなし、一次係数の調整により常温範囲外に位置する変曲点回りに温度特性を回転させて前記頂点温度を常温範囲の最適値に調整するように構成したので、３次関数温度特性の振動子の変曲点より低い温度域の特性を使うことにより、発振回路の温度特性を使用温度範囲で、より平坦にすることのできる

【図面の簡単な説明】

【図１】Ｚ’軸回りに面内回転させたＳＴカット水晶の説明図である。

【図２】Ｚ’軸回りに面内回転させたＳＴカット水晶振動子の温度特性線図である。

【図３】発振回路の構成例である。

【図４】実施形態に係る圧電振動子並びに発振器に組み込んだときの温度特性線図、その部分拡大図である。

【図５】他の実施形態に係る圧電振動子並びに発振器に組み込んだときの温度特性線図、その部分拡大図である。

【図６】発振器温度特性の調整作業を示すフローチャートである。

【図７】３次関数温度特性の調整作業の説明図である。

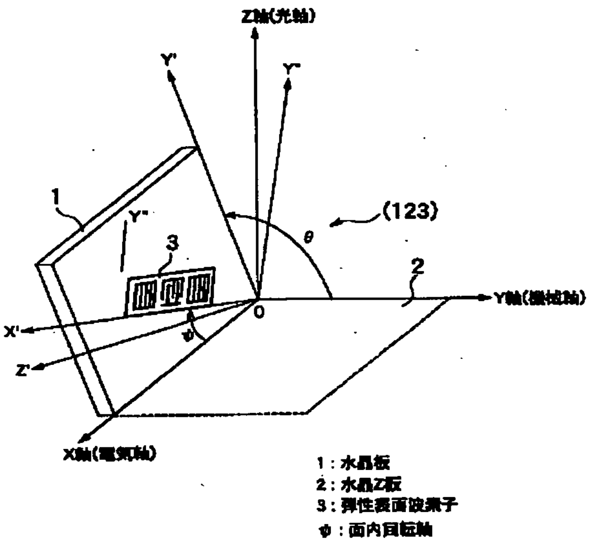
【図８】２次関数温度特性の調整作業の説明図である。

【図９】従来の２次関数温度特性と３次関数温度特性の説明図である。

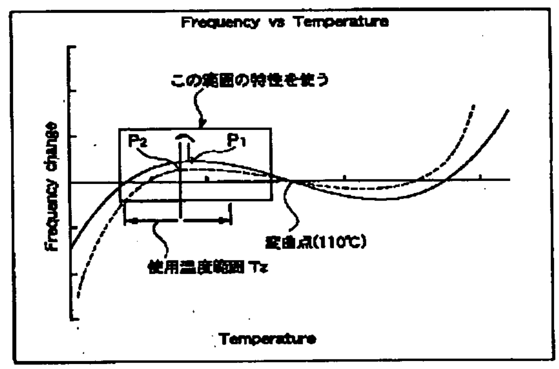
【符号の説明】

１………ＳＴカット水晶板、２………水晶Ｚ板、３………Ｚ’軸回りに面内回転させたＳＴカット水晶振動子、１０………発振器、１２………圧電振動子、１４………位相器、１６………増幅器。

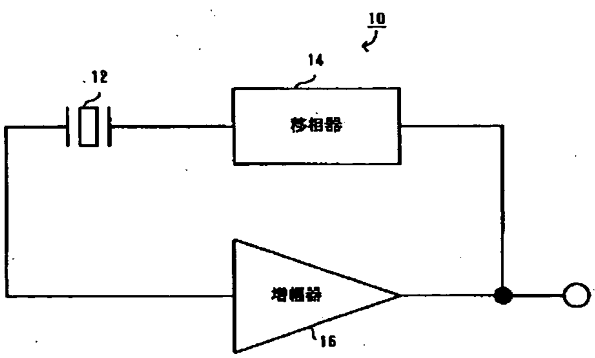
【図１】



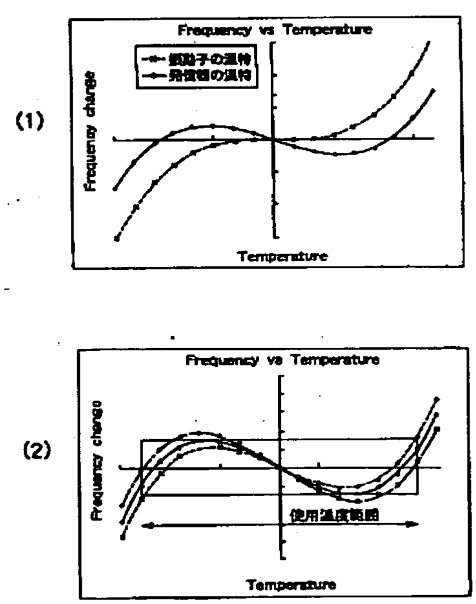
【図２】



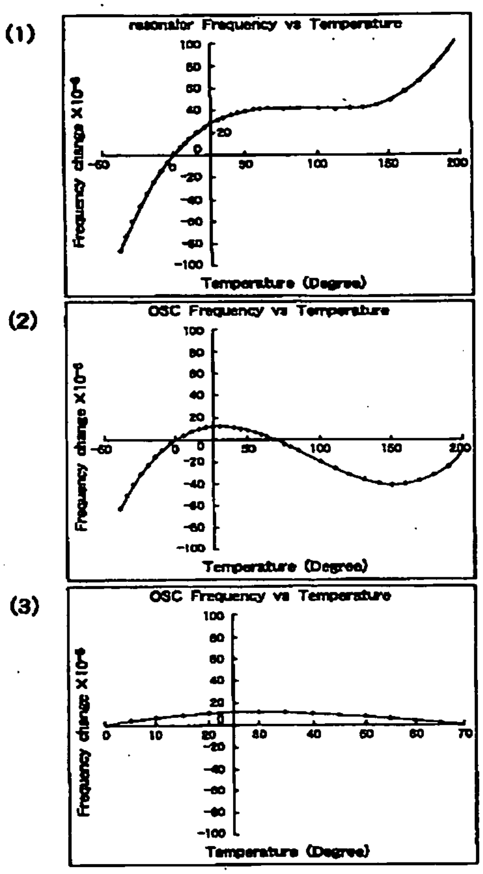
【図３】



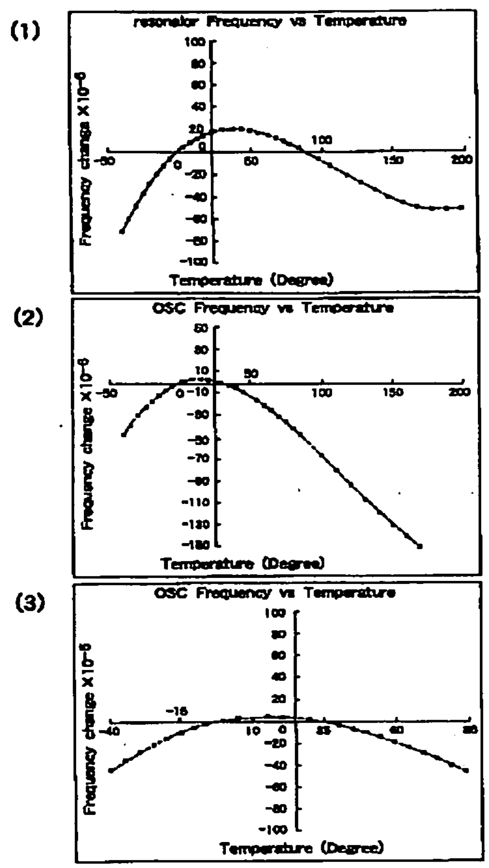
【図７】



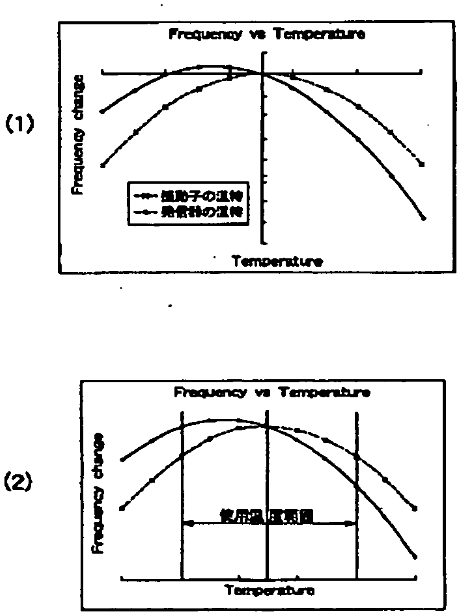
【図4】


(1)
resonator Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)
(2)
OSC Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)
(3)
OSC Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)

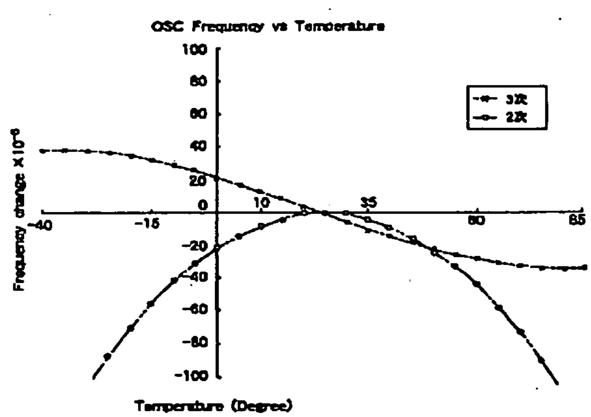
【図5】


(1)
resonator Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)
(2)
OSC Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)
(3)
OSC Frequency vs Temperature
Frequency change X10^-6
Temperature (Degree)

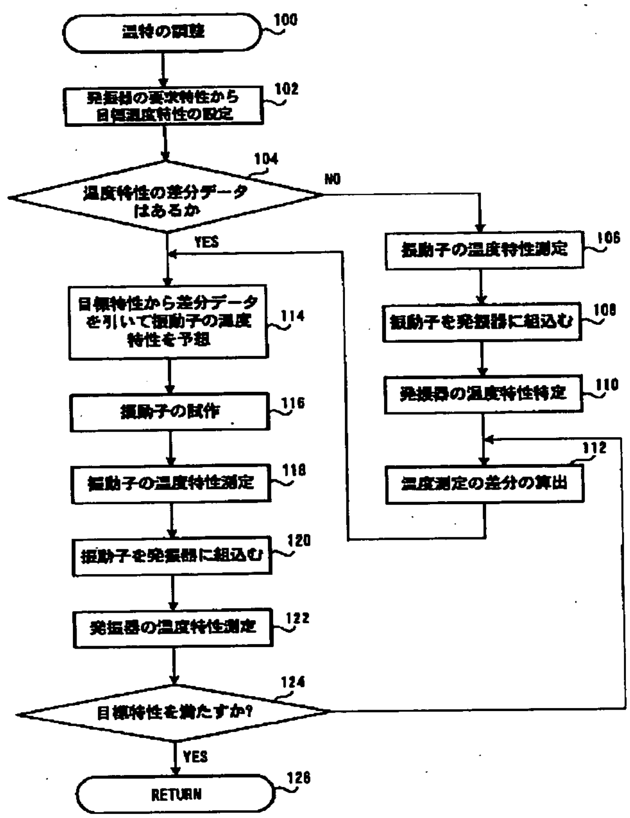
【図8】


(1)
Frequency vs Temperature
Frequency change
振動子の温特
発振器の温特
Temperature
(2)
Frequency vs Temperature
Frequency change
使用温度範囲
Temperature

【図9】


OSC Frequency vs Temperature
3次
2次
Frequency change X10^-6
Temperature (Degree)

【図6】


温特の調整
100
発振器の要求特性から
目標温度特性の設定
102
温度特性の差分データ
はあるか
104
NO
YES
振動子の温度特性測定
106
振動子を発振器に組込む
108
発振器の温度特性特定
110
温度測定の差分の算出
112
目標特性から差分データ
を引いて振動子の温度
特性を予想
114
振動子の試作
116
振動子の温度特性測定
118
振動子を発振器に組込む
120
発振器の温度特性測定
122
目標特性を満たすか?
124
YES
RETURN
126